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CAN NEPA PROTECT BIODIVERSITY?

by

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16. ABSTRACT

Biodiversity has emerged as a prominent issue in the scientific and conservation communities, and is of increasing concern to the general public. As with other "new" environmental problems (e.g., global climate change, stratospheric ozone depletion), biodiversity is difficult to evaluate because it involves slow, cumulative, complex effects that are unquestionably serious but difficult to document. Unlike "traditional" pollution concerns, these new problems are not confined to one location or tied to one development or industry but are regional or global in scope. Given scientific uncertainty about cause-effect relationships, it is very difficult to formulate environmental policy or regulations that adequately address the problem. Biodiversity is also a very broad issue, involving aspects of species richness, species composition, genetic variation, habitat structure, landscape pattern, and ecological and evolutionary processes. Although components of biodiversity are addressed by various pieces of environmental legislation, a comprehensive approach is lacking. a new interpretation of the National Environmental Policy Act (NEPA) could involve the recognition of particular attributes or "indicators" of biodiversity to address in the environmental assessment and review process. We present a hierarchical framework of compositional, structural, and functional biodiversity from which measurable indicators can be selected.

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Abstract

CAN NEPA PROTECT BIODIVERSITY?

Biodiversity has emerged as a prominent issue in the scientific and conservation communities, and is of increasing concern to the general public. As with other "new" environmental problems (e.g., global climate change, stratospheric ozone depletion), biodiversity is difficult to evaluate because it involves slow, cumulative, complex effects that are unquestionably serious but difficult to document. Unlike "traditional" pollution concerns, these new problems are not confined to one location or tied to one development or industry but are regional or global in scope. Given scientific uncertainty about cause-effect relationships, it is very difficult to formulate environmental policy or regulations that adequately address the problem. Biodiversity is also a very broad issue, involving aspects of species richness, species composition, genetic variation, habitat structure, landscape pattern, and ecological and evolutionary processes. Although components of biodiversity are addressed by various pieces of environmental legislation, a comprehensive approach is lacking. A new interpretation of the National Environmental Policy Act (NEPA) could involve the recognition of particular attributes or "indicators" of biodiversity to address in the environmental assessment and review process. We present a hierarchical framework of compositional, structural, and functional biodiversity from which measurable indicators can be selected.

CAN NEPA PROTECT BIODIVERSITY?

The birth of the "environmental movement" in this country reflected a public outcry over the effects of "...the profound influences of population growth, high-density urbanization, industrial expansion, resource exploitation, and new and expanding technological advances..." (NEPA 1970) on the natural environment. Increased environmental awareness and legislation has led to the expenditure of billions of dollars in an attempt to clean up our environment since the passage of the National Environmental Policy Act twenty years ago. Today, we find an environment so altered and degraded that we wonder what those billions of dollars accomplished. Although there have been local successes in fighting pollution, a close look at our planet today suggests that we are losing the war against environmental degradation.

As scientists and policy-makers learn more about pollution and human impacts on the environment, they are discovering a new generation of environmental problems (e.g., loss of biodiversity, massive deforestation, global climate change, stratospheric ozone depletion) that typically involve less visible pollutants and highly diffuse sources. Unlike "traditional" localized pollution episodes, these new problems are not confined to one location or tied to one development or industry but are regional or global in scope. They are fundamentally a problem of too many people using too many resources.

Loss of biodiversity has emerged as one of these "new" environmental concerns. It has become a prominent issue in the scientific and conservation communities, and is of increasing concern to the general public. As with other new environmental problems, loss of biodiversity is difficult to evaluate because it can involve slow, cumulative, complex effects that are serious but uncertain in detail and often difficult to document.

In this paper, we will first discuss biodiversity, what it is and why we value it, and then examine some of the current environmental legislation that addresses biodiversity. The National Environmental Policy Act (NEPA) will be reviewed in terms of its potential to protect biodiversity. Finally, we will suggest an interpretation of NEPA involving the recognition of "indicators" of biodiversity that could be used in the environmental assessment and review process.

What is Biodiversity?

Simply and succinctly, biodiversity refers to the "variety of life and its processes" (H. Salwasser pers. comm.). If we try to understand the meaning behind these words, we quickly abandon simplicity and find ourselves mired in a topic of overwhelming complexity. Ecologists generally study diversity at several levels of biological organization, most notably genetic, species, ecosystem, and landscape. Genetic diversity refers to the diversity of genetic material within species; species diversity is the diversity of species within a defined area; ecosystem diversity is the diversity of interacting plant and animal species in natural communities and their relationships with the physical environment. The spatial arrangement of ecosystems across a landscape is an important higher-level aspect of biodiversity.

To assess diversity at these levels is no mean feat. However, to comprehend fully the diversity of biota, we must go further and consider three primary attributes of ecosystems that determine biodiversity: composition, structure, and function (Franklin et al. 1981). Composition has to with the identity and variety of elements in a collection, and includes species lists and measures of species and genetic diversity. Structure refers to the biotic and abiotic habitat elements or patterns of a system. Function involves ecological and evolutionary processes, including gene flow, disturbances, and

nutrient cycling (Noss 1990). Figure 1 shows the interdependence and connectivity of biodiversity at different levels of organization within each attribute.

For the purposes of this paper, we will focus discussion on those hierarchical levels and attributes best suited for environmental assessment given our current state of knowledge, i.e., species, ecosystem, and landscape diversity within the spheres of compositional and structural diversity (Fig. 2). In evaluating composition and structure, it is useful to keep in mind the ecological and evolutionary processes that underlie these more tangible attributes. Our knowledge of biodiversity is limited, but we cannot wait for all the puzzle pieces to fit. We must start sharpening those tools we do have for potential use in environmental assessment.

Values of and Threats to Biodiversity

The basic issue that drives all concerns about biodiversity is the accelerating and irreplaceable loss of genes, species, populations, and ecosystems. Associated with this loss is the loss of products obtained from nature (presently or potentially), possible disruption of essential ecological processes and services, and loss of options for biological and cultural adaptation to an uncertain future. In addition, a growing number of Americans believe that species, ecosystems, and other elements of biodiversity (i.e., the natural world) are valuable in and of themselves.

Patterns and processes of biodiversity currently are deteriorating in most regions of the world, a problem that many biologists consider to be of crisis proportions. Although some threats to biodiversity such as the enhanced greenhouse effect, are global in scope, biodiversity is being lost mostly due to local and regional impacts that are addressable in an environmental assessment process.

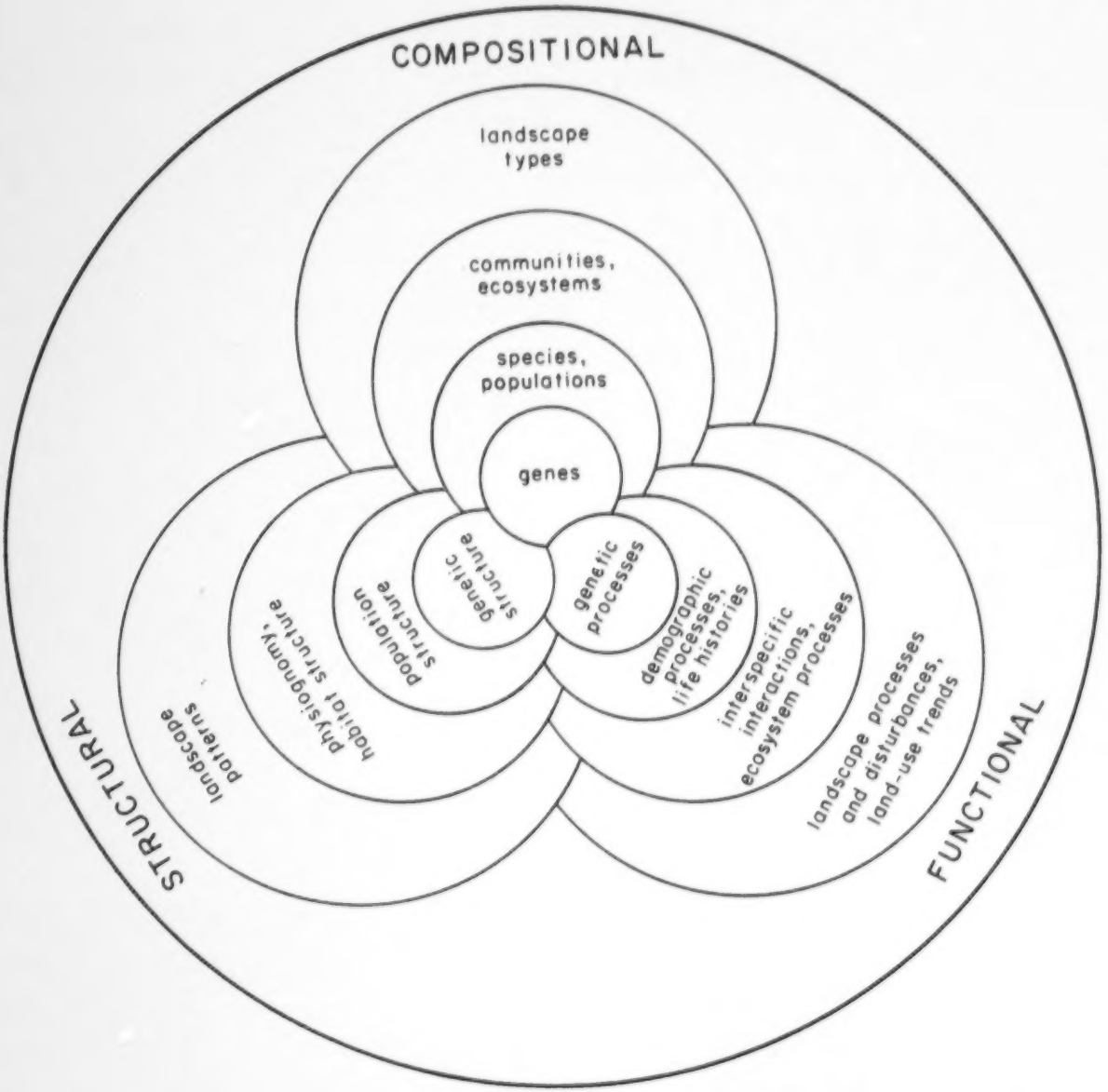

Figure 1. Interdependence and connectivity of different levels of biological organization within structural, functional, and compositional spheres (from Noss 1990).

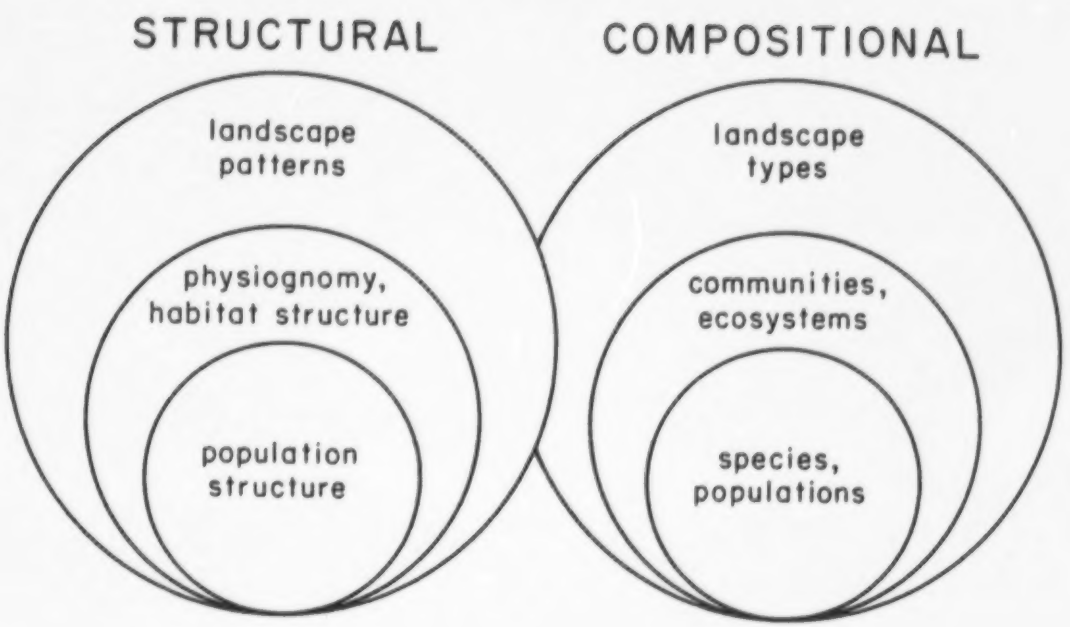

Figure 2. Hierarchical levels and attributes of biological diversity best suited for environmental assessment (adapted from Noss 1990).

Estimates of the annual global rate of species extinction range from 1,000 to 10,000 times that before human intervention (Wilson 1988). Many species not yet in immediate danger of extinction have been severely reduced in numbers and geographic range. In addition to species loss, communities are changing as sensitive species decline and are replaced by opportunistic weedy species, often exotics. Some ecosystems are disappearing altogether. Endangered ecosystems in the U.S. include tropical hardwoods (in Florida and Hawaii), tallgrass prairie, Palouse prairie, long-leaf wiregrass communities, Florida scrub, and old-growth forests of all types. Biodiversity faces threats primarily from the following stressors, all of which are caused or aggravated by human population growth and resource consumption:

1. habitat modification
    - o physical alteration of habitat, especially activities that lead to habitat fragmentation;
2. pollutants
    - o abiotic (i.e., heavy metals, acid rain, organic contaminants)
    - o biotic (i.e., invasive, introduced, bioengineered organisms)
3. climate change
    - o anthropogenic-induced changes (short-term)
    - o natural fluctuations (long-term)
4. exploitation (i.e., harvest, removal, harassment).

Current Legislation Addressing Biodiversity

Given the degree of scientific uncertainty surrounding biodiversity, it will be challenging to formulate environmental policy and regulations that adequately address this issue. Although most of what we now call biodiversity has been of concern to biologists, conservationists, and governments for a long time, biodiversity is relatively new as a self-contained policy issue. At present, policy-makers are searching for the appropriate "regulatory traction" to address the biodiversity issue.

HR 1268 would amend NEPA to require assessment of biodiversity in Environmental Impact Statements (EISs). Because the status of HR 1268 is uncertain, and our biological resources cannot be put on hold until comprehensive legislation is in place, it is prudent to evaluate NEPA for its ability to encourage protection of biodiversity.

NEPA and the Conservation of Biodiversity

The goal of NEPA is to promote the health of all biological resources, therefore, it is an appropriate legal mechanism through which to promote the conservation of biological diversity. NEPA requires the preservation of "..important historic, cultural and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity,.." (emphasis added). We believe that "diversity" can properly be interpreted as including biodiversity.

Central to NEPA is the Environmental Impact Statement (EIS) through which "environmental amenities and values...(are) given appropriate consideration in decision making along with economic and technical considerations" (Carlson 1988). All federal agencies are required to prepare detailed statements assessing the environmental impacts of and alternatives to major federal actions significantly affecting the environment. A secondary mechanism requires all federal agencies to review their authorizing statutes, regulations, and policies and procedures to ensure compliance with the "intent, purposes, and procedures set forth in this Act".

Although most EISs only address a few aspects of biological diversity (i.e., threatened and endangered species), reductions or alterations of biological diversity are clearly "environmental impacts". EISs do not examine the cumulative spatial pattern of impacts in relation to the long-term

maintenance of biodiversity. For example, we know that habitat fragmentation is one of the most serious threats to biodiversity, as it leads to diminished contiguous habitat area, isolation of populations, and detrimental physical and biological impacts (edge effects) on isolated habitat patches from surrounding areas. While single actions may not, in themselves, seriously compromise the biodiversity of a given region, cumulative isolation and fragmentation of natural areas from multiple actions can ultimately lead to severe reduction in biodiversity. Impacts, within the context of the NEPA EIS review process, should be interpreted to include such cumulative effects.

It is likely that the Council on Environmental Quality (CEQ) will soon be directed to prepare guidelines for the consideration of biological diversity in EISs (D. Blockstein pers. comm.). Report language from the Senate Environment Committee (1988) directed the CEQ to determine whether biological diversity was being adequately addressed in EISs and to prepare new guidelines if necessary. HR 1268 would amend NEPA to "... require explicit assessment of effects on biological diversity in environmental impact statements;". Section 5 of HR 1268 would clarify the diversity provision in Section 101(b) of NEPA by inserting "including biological diversity" after "which supports diversity".

In light of these potential amendments to NEPA and given NEPA's current broad mandate to protect the environment, guidelines for the consideration of biodiversity in EISs should be developed now. It is important to note that aspects of biodiversity are addressed in the NEPA process; bills or legislation would simply make this focus explicit and comprehensive.

How is Biodiversity Measured?

It is one thing to mandate that diversity be considered, it is quite another to determine how diversity will be considered. How will those people

involved in the actual writing and reviewing of EISs be able to give more than cursory attention to biodiversity? By what yardstick will biodiversity be measured? Because the real world is complex and constantly changing, it is difficult to "measure" biodiversity in a meaningful way. Unlike the physical sciences, ecology has few, if any, laws. There are no nice ordered charts like the periodic table in ecology. Clear and generally accepted measures of biodiversity do not exist.

Measuring biodiversity is more than a numbers game. Most ecologists will agree that "richness", the number of species, ecosystems, habitats, or any other group of things in a defined area is not, by itself, an appropriate measure of biodiversity (Noss 1990). In fact, species richness can be a misleading indicator of biotic value, if many species in the sample are exotic, "weedy", or highly tolerant of human disturbance or pollution. (Noss 1983, Norse et al. 1986).

Because it is impractical, if not impossible, to measure accurately the total composition and diversity of biota in a given area, short cuts must be taken. The identification and evaluation of measurable surrogates or "indicators" is necessary for the assessment of biodiversity. If we crystallize the components of biodiversity into measurable elements, it is possible to identify particular indicators to use in the environmental assessment and review process.

Indicators

Probably the best known use of an indicator is the coal miner's canary. In this example, miners took a caged canary into the mine with them to detect toxic fumes. An unconscious canary indicated the presence of lethal fumes and alerted the miners in time to make a hasty, and life-saving, retreat from the mine. The miner's canary is one-dimensional in its usefulness as an

indicator. The canary could not warn of a potential cave-in, a hungry bear waiting just ahead, or a potentially fatal equipment malfunction.

Ideally, environmental assessments should consider a range of ecological parameters at several levels of organization (Karr et al. 1986). Like the canary, no one indicator can "do it all". We suggest a characterization of biodiversity that identifies the major components at several levels of organization. This would provide a framework for selecting specific indicators by which to evaluate biodiversity in any geographical area of concern (Table 1). Such a framework would allow us to (1) characterize the biodiversity of an area in a way comparable to other areas; and (2) identifyspecific aspects of biodiversity that can be used as indicators to monitor and assess the overall status or health of an ecosystem.

Selecting Indicators

Different indicators are useful for different environmental assessment questions. An important point in the selection of appropriate indicators is the question, "What are we assessing and why?". In application, many indicators will be specific to ecosystems. For example, coarse woody debris is a structural element critical to biodiversity in many old-growth forests, such as in the Pacific Northwest, but may not be important in more open-structured habitats, including forest types subject to frequent fires (Noss 1990).

The following is a list of characteristics that should be considered when choosing indicators. Ideal indicators would be (Cook 1976, Sheehan 1984, Munn 1988):

1. sufficiently sensitive to provide an early warning of change (hypersensitive to stress),

Table 1. Adapted from Noss (1990)

Levels of Organization	Indicators	
	Composition	Structure
Regional Landscape	identity, distribution, richness, and proportions of patch (habitat) types and multi-patch landscape types; species richness and endemism	heterogeneity, connectivity, spatial linkage, patchiness, porosity, contrast, grain size, fragmentation, configuration, juxtaposition, patch size, frequency distribution, edge-interior ratio, pattern of habitat layer distribution
Community-Ecosystem	identity, relative abundance, frequency, richness, evenness, and diversity of species and guilds; proportions of endemic, exotic, threatened, and endangered species; dominance-diversity curves; life-form proportions; similarity coefficients; C4:C3 plant species ratios	substrate and soil variables; slope and aspect; vegetation biomass and physiognomy; foliage density and layering; horizontal patchiness; canopy openness and gap proportions; abundance, density, and distribution of key physical feature (e.g., cliffs, outcrops, sinks) and structural elements (snags (down logs); water and resource (e.g., mast) availability; snow cover
Population-Species	absolute or relative abundance; frequency; importance or cover value; biomass; density	dispersion (microdistribution); range (macrodistribution); population structure (sex ratio, social structure; ratio, age habitat variables (see community-ecosystem structure, above); within-individual morphological variability

2. distributed over a broad geographical area, or otherwise widely applicable,
3. capable of providing a continuous assessment over a wide range of stress,
4. relatively independent of sample size;
5. easy to measure, collect, assay, and/or calculate (in the case of an index);
6. able to differentiate between natural cycles or trends and those induced by anthropogenic stress; and
7. relevant to ecologically significant phenomena.

No single indicator will possess all of these desirable properties; a set of complementary indicators is required. Ideally, indicators would be selected by biologists familiar with local and regional ecology, but who have no vested interest in the outcome of the environmental assessment.

Once indicators have been selected and measured, the status or health of the population or ecosystem can be evaluated and the information incorporated in the section on the affected environment of the EIS. Predictions can be made about how the proposed project and its alternatives may affect the identified indicators and the underlying endpoint of biodiversity. Then, environmental consequences, including impacts on biodiversity, can be better appreciated.

The impacts of federal projects on biodiversity can be assessed adequately only if those impacts are monitored during the course of the project and beyond. Ongoing monitoring goes beyond current NEPA requirements, however, this is an important part in the assessment of impacts to biodiversity. If the indicators chosen in an EIS are monitored in the affected environment and in a nearby control site (such as a nature reserve),

then impacts can be assessed statistically, particularly if impacted and control samples can be replicated.

Conclusion

Biodiversity has been thrust forward as a new environmental concern. Biodiversity encompasses many concerns for which assessment methodologies are not yet well-developed. This creates difficulties in setting goals or standards for factoring biodiversity into decision-making.

NEPA is an appropriate legal mechanism through which to ensure the conservation of biological diversity is addressed in federal decisions. NEPA mandates that all federal agencies prepare detailed statements (EIS's) assessing the environmental impacts of and alternatives to major federal actions significantly affecting the environment. Measuring biodiversity by particular relevant indicators not only provides information for an assessment of ecosystem health, but also provides information on possible direct, indirect, and cumulative effects of a proposed federal action on biological diversity as an endpoint in itself.

We do not suggest that NEPA alone can protect biodiversity. A major shortcoming of NEPA is that it applies only to federal activities and does not apply to the local/state/private sector. Also, courts have held that EIS requirements are primarily procedural, and documenting impact for disclosure to the public rather than requiring protection.

In conclusion, we could rephrase our title question "Can NEPA protect biodiversity?" to " Will NEPA protect biodiversity?" Certainly protecting biodiversity will be one of the major scientific challenges faced by NEPA in the coming years.

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